DOE/FE-0198P

Comprehensive Report to Congress Clean Coal Technology Program

10 MW Demonstration of Gas Suspension Absorption

A Project Proposed By:
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1.0 EXECUTIVE SUMMARY

In September 1988, Congress provided $575 million to conduct cost-shared Clean Coal Technology (CCT) projects to demonstrate technologies that are capable of retrofitting or repowering existing facilities. To that end, a Program Opportunity Notice (PON) was issued by the Department of Energy (DOE) in May 1989, soliciting proposals to demonstrate innovative energy efficient technologies that were capable of being commercialized in the 1990's, and were capable of (1) achieving significant reductions in the emissions of sulfur dioxide and/or the oxides of nitrogen from existing facilities to minimize environmental impacts such as transboundary and interstate pollution and/or (2) providing for future energy needs in an environmentally acceptable manner.

In response to the PON, 48 proposals were received in August 1989. After evaluation, 13 projects were selected in December 1989 as best furthering the goals and objectives of the PON. The projects were located in 10 different states and represented a variety of technologies. A proposal by AirPol, Inc. was one of those selected for negotiation.

The AirPol, Inc. project will demonstrate the Gas Suspension Absorption (GSA) process. This process uses a unique absorber in which the flue gas is contacted with lime to remove up to 90% of the sulfur dioxide (SO_2) in the flue gas at a low calcium to sulfur stoichiometric ratio (approximately 1.3).

The heart of the process is the GSA reactor. The flue gas flows upward through the vertical reactor vessel located between the air preheater and the particulate removal equipment. Fresh lime is injected as a slurry through a nozzle located in the base of the reactor. The quantity of fresh lime used is based on the SO_2 content of the gas and the amount of water is controlled to cool the gas to the desired approach to its saturation temperature. Dry, partially spent lime is collected by a cyclone located downstream of the reactor and recycled back to the absorber. The gas then passes through an electrostatic precipitator (ESP) where the balance of the sorbent and fly ash are removed and the clean flue gas exits the plant through the stack.

The project is located at the Shawnee Test Facility (STF) which is part of the Shawnee Fossil Plant in West Paducah, Kentucky. This Plant, owned by the Tennessee Valley Authority (TVA), consists of ten 150 megawatt electric (MWe) coal-fired boilers. Nine of the boilers burn low-sulfur coal and the tenth is permitted to burn high sulfur coal. This project will be carried out on a slip-stream equal to about 10 MWe, taken from the boiler burning high-sulfur coal.

This project schedule will be carried out over a 26 month period and the activities include design, permitting, installation of equipment, baseline operation, experimental tests, demonstration run, data analysis and reporting. The total estimated project cost is $6,920,679. The co-funders are AirPol with the backing of its parent company FLS miljo a/s (FLS) ($2,323,679) and the TVA ($2,597,000). The project is expected to begin in August 1990 and is scheduled for completion in September 1992.

2.0 INTRODUCTION AND BACKGROUND

2.1 Requirement for a Report to Congress

On September 27, 1988, Congress made available funds for the third clean coal demonstration program (CCT-III) in Public Law 100-446, "An Act Making Appropriations for the Department of the Interior and Related Agencies for the Fiscal Year Ending September 30, 1989, and for Other Purposes" (the "Act"). Among other things, this Act appropriates funds for the design, construction, and operation of cost-shared, clean coal projects to demonstrate the feasibility of future commercial applications of such "... technologies capable of retrofitting or repowering existing facilities ...." On June 30, 1989, Public Law 101-45 was signed into law, requiring that CCT-III projects be selected no later than January 1, 1990.

Public Law 100-446 appropriates a total of $575 million for executing CCT-III. Of this total, $6.906 million are required to be reprogrammed for the Small Business and Innovative Research Program (SBIR) and $22.548 million are designated for Program Direction Funds for costs incurred by DOE in implementing the CCT-III program. The remaining, $545.546 million was available for award under the PON.

The purpose of this Comprehensive Report is to comply with Public Law 100-446, which directs the Department to prepare a full and comprehensive report to Congress on each project selected for award under the CCT-III Program.

2.2 Evaluation and Selection Process

DOE issued a draft PON for public comment on March 15, 1989, receiving a total of 26 responses from the public. The final PON was issued on May 1, 1989, and took into consideration the public comments on the draft PON. Notification of its availability was published by DOE in the Federal Register and the Commerce Business Daily on March 8, 1989. DOE received 48 proposals in response to the CCT-III solicitation by the deadline, August 29, 1989.

2.2.1 PON Objective

As stated in PON Section 1.2, the objective of the CCT-III solicitation was to obtain "proposals to conduct cost shared Clean Coal Technology projects to demonstrate innovative, energy efficient technologies that are capable of being commercialized in the 1990's. These technologies must be capable of (1) achieving significant reductions in the emissions of sulfur dioxide and/or the oxides of nitrogen from existing facilities to minimize environmental impacts such as transboundary and interstate pollution and/or (2) providing for future energy needs in an environmentally acceptable manner."

2.2.2 Qualification Review

The PON established seven Qualification Criteria and provided that, "In order to be considered in the Preliminary Evaluation Phase, a proposal must successfully pass Qualification." The Qualification Criteria were as follows:

(a) The proposed demonstration project or facility must be located in the United States.

(b) The proposed demonstration project must be designed for and operated with coal(s) from mines located in the United States.

(c) The proposer must agree to provide a cost share of at least 50 percent of total allowable project cost, with at least 50 percent in each of the three project phases.

(d) The proposer must have access to, and use of, the proposed site and any proposed alternate site(s) for the duration of the project.

(e) The proposed project team must be identified and firmly committed to fulfilling its proposed role in the project.

(f) The proposer agrees that, if selected, it will submit a "Repayment Plan" consistent with PON Section 7.4.

(g) The proposal must be signed by a responsible official of the proposing organization authorized to contractually bind the organization to the performance of the Cooperative Agreement in its entirety.

2.2.3 Preliminary Evaluation

The PON provided that a Preliminary Evaluation would be performed on all proposals that successfully passed the Qualification Review. In order to be considered in the Comprehensive Evaluation phase, a proposal must be consistent with the stated objective of the PON, and must contain sufficient business and management, technical, cost, and other information to permit the Comprehensive Evaluation described in the solicitation to be performed.

2.2.4 Comprehensive Evaluation

The Technical Evaluation Criteria were divided into two major categories: (1) the Demonstration Project Factors were used to assess the technical feasibility and likelihood of success of the project, and (2) the Commercialization Factors were used to assess the potential of the proposed technology to reduce emissions from existing facilities, as well as to meet future energy needs through the environmentally acceptable use of coal, and the cost effectiveness of the proposed technology in comparison to existing technologies.

The Business and Management criteria required a Funding Plan and an indication of Financial Commitment. These were used to determine the business performance potential and commitment of the proposer.

The PON provided that the Cost Estimate would be evaluated to determine the reasonableness of the proposed cost. Proposers were advised that this determination "will be of minimal importance to the selection," and that a detailed cost estimate would be requested after selection. Proposers were cautioned that if the total project cost estimated after selection is greater than the amount specified in the proposal, DOE would be under no obligation to provide more funding than had been requested in the proposer's Cost Sharing Plan.

2.2.5 Program Policy Factors

The PON advised proposers that the following program policy factors could be used by the Source Selection Official to select a range of projects that would best serve program objectives:

(a) The desirability of selecting projects that collectively represent a diversity of methods, technical approaches, and applications.

(b) The desirability of selecting projects in this solicitation that contribute to near term reductions in transboundary transport of pollutants by producing an aggregate net reduction in emissions of sulfur dioxide and/or the oxides of nitrogen.

(c) The desirability of selecting projects that collectively utilize a broad range of U.S. coals and are in locations which represent a diversity of EHSS, regulatory, and climatic conditions.

(d) The desirability of selecting projects in this solicitation that achieve a balance between (1) reducing emissions and transboundary pollution and (2) providing for future energy needs by the environmentally acceptable use of coal or coal-based fuels.

The word "collectively" as used in the foregoing program policy factors, was defined to include projects selected in this solicitation and prior clean coal solicitations, as well as other ongoing demonstrations in the United States.

2.2.6 Other Considerations

The PON provided that in making selections, DOE would consider giving preference to projects located in states for which the rate-making bodies of those states treat the Clean Coal Technologies the same as pollution control projects or technologies. This consideration could be used as a tie breaker if, after application of the evaluation criteria and the program policy factors, two projects receive identical evaluation scores and remain essentially equal in value. This consideration would not be applied if, in doing so, the regional geographic distribution of the projects selected would be altered significantly.

2.2.7 National Environmental Policy Act (NEPA) Compliance

As part of the evaluation and selection process, the Clean Coal Technology Program developed a procedure for compliance with the National Environmental Policy Act of 1969, the Council on Environmental Quality (CEQ) NEPA regulations (40 CFR Parts 1500-1508) and the DOE guidelines for compliance with NEPA (52 FR 47662, December 15, 1987).

This procedure included the publication and consideration of a publicly available Final Programmatic Environmental Impact Statement (DOE/EIS-0146) issued in November 1989, and the preparation of confidential preselection project-specific environmental reviews for internal DOE use. DOE also prepares publicly available site-specific documents for each selected demonstration project as appropriate under NEPA.

2.2.8 Selection

After considering the evaluation criteria, the program policy factors, and the NEPA strategy as stated in the PON, the Source Selection Official selected 13 projects as best furthering the objectives of the CCT-III PON.

Secretary of Energy, Admiral James D. Watkins, U.S. Navy (Retired), announced the selection of 13 projects on December 21, 1989. In his press briefing, the Secretary stated he had recently signed a DOE directive setting a 12 month deadline for the negotiation and approval of the 13 cooperative agreements to be awarded under the CCT-III solicitation.

3.0 TECHNICAL FEATURES

3.1 Project Description

The AirPol project will demonstrate that the GSA process is a reliable, efficient and economic means of removing SO_2 from flue gas. It will be the first demonstration of GSA on flue gas generated by the combustion of U.S. bituminous, high-sulfur coals.

The primary advantage of the GSA process is that it is a relatively simple process that is inexpensive to install and operate, much like the dry sorbent injection or spray drying technologies. However, it is capable of 90% SO_2 removal, much like the more complex (and costly) wet FGD technologies. The GSA consumes less lime than conventional dry systems due to its recirculation capabilities.

The project is located at the TVA's Shawnee Fossil Plant (Figure 1). This Plant consists of ten identical boilers, each with a nameplate rating of 175 MW with a net power generating capacity of slightly over 150 MWe. The GSA facility will be installed at the Shawnee Test Facility (STF), which is part of this Plant. The GSA facility will treat a portion of the flue gas equivalent to about 10 MWe from the No. 9 unit, which is permitted to burn high sulfur coal. The STF, which has been in operation for over 15 years, is currently being used to test a spray dryer. The GSA equipment will be installed when the spray dryer tests are complete. Existing equipment (e.g., lime handling) will be used to the extent practicable.

This demonstration project will confirm whether GSA is capable of 90% SO_2 removal at a low calcium to sulfur ratio (Ca:S), and whether GSA is a technically and economically viable technology to treat flue gas from boilers that use U.S. high-sulfur coals. The demonstration will also show whether the process is capable of removing a high percentage of chlorides from the flue gas.

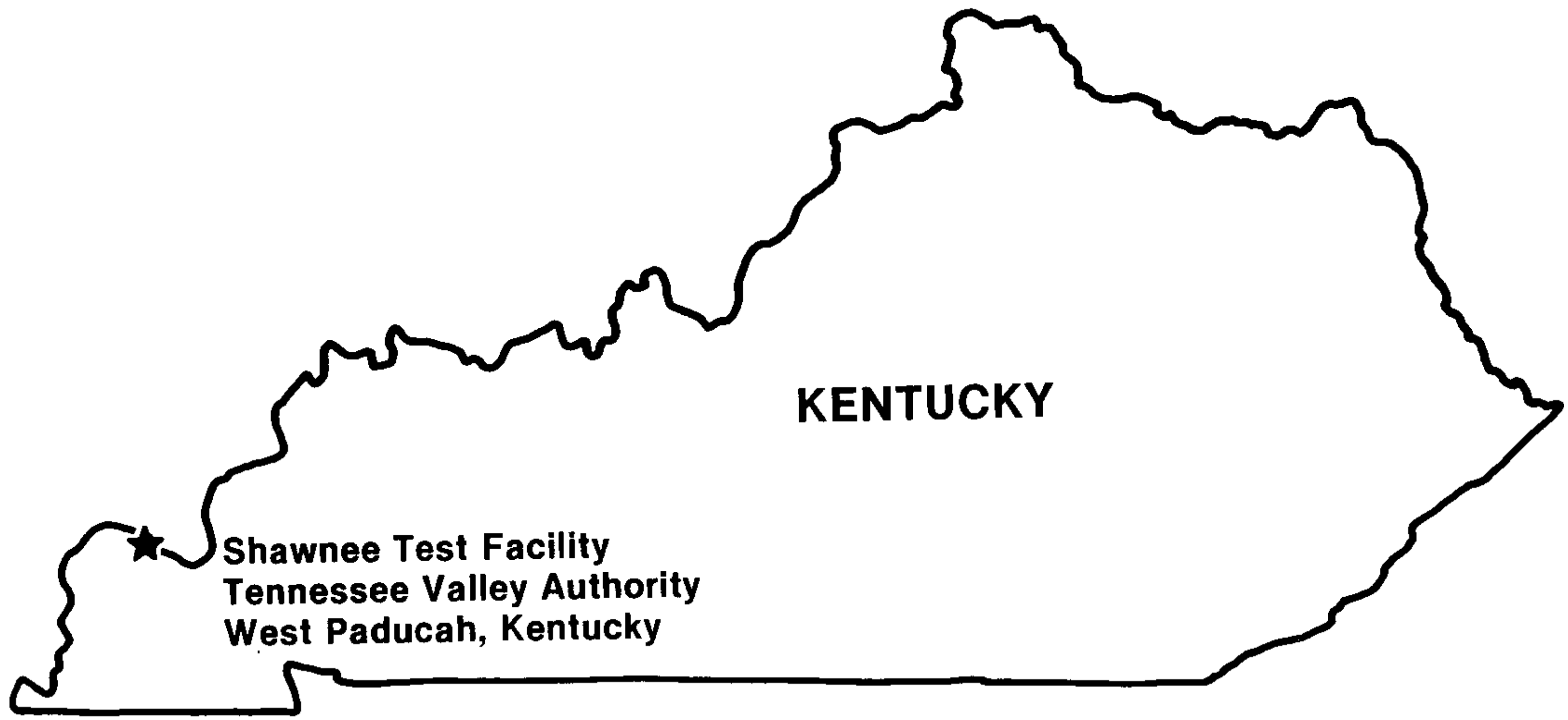

FIGURE 1. GAS SUSPENSION ABSORPTION PROJECT SITE.

NO./19,522

3.1.1 Project Summary

Project Title:	10 MW Demonstration of Gas Suspension Absorption
Proposer:	AirPol, Inc.
Project Location:	Shawnee Test Facility West Paducah, McCracken County, Kentucky
Technology:	Gas Suspension Absorption
Application:	Retrofit to boilers
Types of Coal Used:	Eastern High-Sulfur Bituminous (2.75-4.5% sulfur)
Product:	Environmental Control Technology
Project Size:	10 MW
Project Start Date:	August 1, 1990
Project End Date:	September 30, 1992

3.1.2 Project Sponsorship and Cost

Project Sponsor:	AirPol, Inc.	
Co-Funder:	Tennessee Valley Authority	
Estimated Project Cost:	$6,920,679	
Project Cost Distribution:	Participant Share (%)	DOE Share (%)
	71.1	28.9

3.2 Gas Suspension Absorption Process

3.2.1 Overview of Process Development

The GSA was originally developed as a cyclone preheater for raw cement kiln feed (limestone and clay). The GSA system provided both capital cost and energy savings by allowing the use of a shorter kiln and by lowering overall fuel consumption. The GSA system was later used to calcine limestone in Australia (1979), alumina in India (1986) and dolomite in Norway (1986).

The GSA system was developed with both a slaked lime slurry feed and a recycle solids feed to the bottom of the gas suspension reactor which functions as both an acid gas absorber and a slurry dryer.

Since 1985, FLS has tested a GSA unit at a Danish power plant. The size of this unit is 10 MWe. At this installation, only SO_2 absorption was tested and the GSA technology was found to be equal to, or better than, competing processes with respect to SO_2 absorption. During the same period hydrogen chloride (HCl) absorption was tested at a 2 MWe laboratory facility and removal rates of at least 90% were obtained at a Ca:S ratio of 1.3.

During the 10 MWe SO_2 absorption tests, the GSA was operated continuously. Data was taken at two minute intervals by a computerized data acquisition system. Data acquired included temperatures and SO_2 concentrations at critical points as well as gas flow rates, slurry flow rates and the concentration of lime in the slurry. After the test period, the data was evaluated and analyzed to develop a mathematical model which predicts the performance of GSA. This model indicates that the approach of the flue gas temperature to its dew point is very important.

The first commercial use of GSA was in 1988 at the KARA waste-to-energy plant in Roskilde, Denmark. This unit is rated at 15.6 MWe and has demonstrated the ability of GSA to efficiently remove HCl and SO_2 acid gas.

The CCT project will demonstrate whether the GSA technology can effectively and economically treat flue gas produced by medium- and high-sulfur, U.S. coals. This project is the next logical step in the commercialization of the GSA technology.

3.2.2 Process Description

The process concept is shown in Figure 2.

The flue gas coming from the boiler is conveyed to the bottom of the reactor and mixed with suspended solids and lime slurry. The slurry is carried upwards in the reactor by the gas stream, during which the slurry is dried and SO_2 is absorbed and neutralized by reaction with the lime. The major product to be discharged is calcium sulfite and calcium sulfate.

The partially cleaned flue gasses are passed on via the separating cyclone, which removes a portion of the solids for reinjection and exit, to a dust collector which removes the reaction products and fly ash. The flue gases which have now been cleaned are now released into the atmosphere via the stack.

About 99% of the solids exiting the reactor are fed back to the reactor via a screw conveyor, while only about 1% leave the system in the form of a solid waste. The solids are returned to the inlet of the reactor, thereby maintaining a high concentration of solids in the reactor. This ensures an effective absorption of gases and continuous cleaning of the inner surface of the reactor. It also results in lower operating costs than those experienced with conventional semi-dry scrubbers.

The lime slurry is prepared from hydrated lime in a separate unit and is pumped to the nozzle in the bottom of the reactor. The flow of the lime slurry is controlled by continuous measurement of the acid content upstream of the reactor and downstream of the dust collector. Also, dilution water is pumped into the nozzle to lower gas temperature to the required operating temperature of the reaction which is above 200 degrees F.

The process chemistry of the GSA system can be described by several primary and secondary reactions.

The primary reactions take place in suspended solids containing lime:

$$Ca(OH)_2\,(aq) + SO_2\,(aq) \text{ --> } CaSO_3 \cdot 1/2\ H_2O(s) + 1/2\ H_2O$$

$$Ca(OH)_2\,(aq) + SO_3\,(aq) + H_2O(l) \text{ --> } CaSO_4 \cdot 2\ H_2O(s)$$

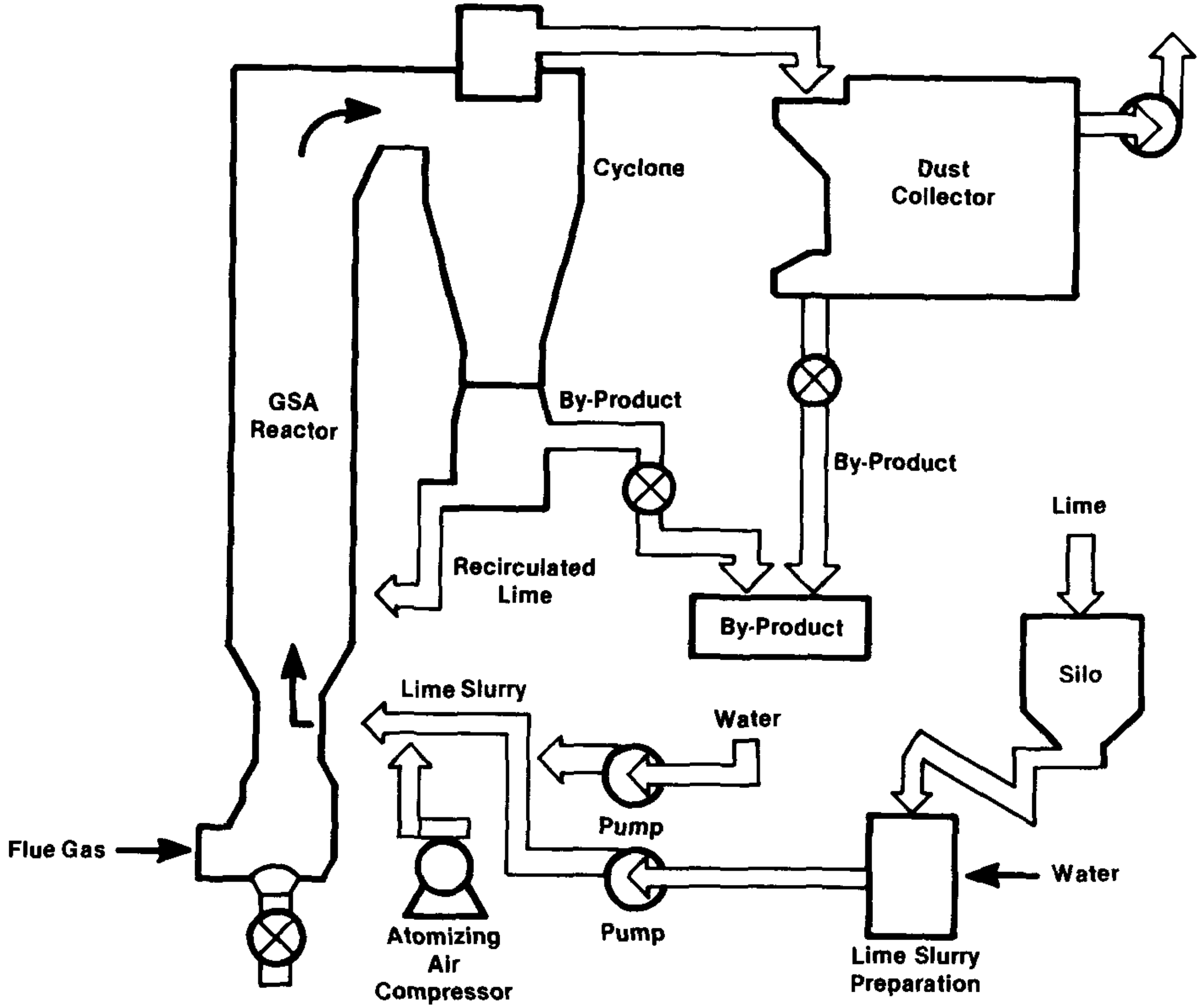

FIGURE 2. GSA PROCESS SCHEMATIC.

NO./19,525

In addition to the primary reactions the following secondary reactions also take place:

$$Ca(OH)_2\ (aq) + 2\ HCl\ (aq) + 4\ H_2O(l) \dashrightarrow CaCl_2 \cdot 6\ H_2O(s)$$

$$Ca(OH)_2\ (aq) + CO_2\ (aq) \dashrightarrow CaCO_3(s) + 2\ H_2O(l)$$

$$CaSO_3\ (aq) \cdot 1/2\ H_2O + 1/2\ O_2\ (aq) + 3\ 1/2\ H_2O(l) \dashrightarrow CaSO_4 \cdot H_2O(s)$$

Thus, in addition to fly ash, the solid waste is a mixture of calcium sulfite, calcium sulfate, calcium chloride and calcium carbonate with the sulfate and sulfite being the predominant species.

The technical objectives of the GSA demonstration project are to:

- Demonstrate SO_2 removal in excess of 90% using high sulfur U.S. coal.
- Optimize recycle and design parameters to increase efficiencies of lime reagent utilization and SO_2 removal.
- Compare removal efficiency and cost with existing Spray Dryer/Electrostatic Precipitator technology.

3.3 General Features

3.3.1 Evaluation of Developmental Risk

As described earlier, this technology has been used commercially in several calcining application and has been tested at the 10 MWe level in an electric utility application. In addition, a commercial installation went on stream in 1988. This GSA unit, rated at 15.6 MWe equivalent, was attached to a steam producer that burns waste in a rotary kiln combustor at Roskilde, Denmark. These commercial and test applications allowed FLS to collect extensive data which was used to generate a computer model which predicts system performance and allows the designer to specify the optimum system for each application.

However, as with any new technology there is some element of risk in its continued development. One risk is that if slurry impinges on the walls prior to drying, solids build-up may occur and may limit performance of the system and increase vessel weight.

Another potential risk involves the very high recirculation rate of solids. This will result in a very high solids load in the flue gas. With such a high solids load it is possible that, if the cyclone performance is less than design for any reason (e.g. off-spec particle size, lower gas flow or available pressure drop), the ESP may be overloaded with solids.

Another risk centers around the limited experience with coal-fired units and the absence of any experience with high-sulfur, U.S. coal. There is some slight chance that the high sulfur removal rates at the Ca:S ratio of 1.3 experienced elsewhere will not be attained. Higher calcium to sulfur ratios would have an adverse economic impact on the process.

3.3.1.1 Similarity of Project to Other Demonstration/ Commercial Efforts

There are a number of projects underway which use a sorbent (usually calcium based) to remove SO_2 from flue gas. The Pure Air and Southern Company Services/Chiyoda projects both use a lime slurry to remove SO_2 from flue gas. Both projects use special scrubber designs that are being demonstrated in projects that were funded in the second round of the CCT program. Conventional wet flue gas desulfurization (FGD) systems, using lime or limestone, are widely used commercially.

Sorbent injection in slurry form is used in spray dryers in which a sorbent (usually calcium based) is injected into a vessel in the flue gas duct. The slurry is quickly dried. SO_2 is absorbed both during and after the drying phase. There are also some technologies which inject a dry sorbent into the upper part of the boiler or at some point in the duct work. Both types of systems use conventional particulate removal equipment to remove the spent sorbent. Sorbent recycle is also utilized to some degree in many of the processes. Typically these systems will remove 50-70% of the SO_2 and require Ca:S ratios of 1.5 or more. There are a number of projects involving dry sorbent injection or spray dryers (usually in conjunction with an NO_x control technology) in the first three rounds of the CCT program. The Participant believes that the design of the GSA system will result in better efficiency and more economical operation than competing dry or semi-dry systems.

3.3.1.2 Technical Feasibility

As previously described, there is widespread interest in dry and semi-dry sorbent injection as a means to remove SO_2 from flue gas. This interest is demonstrated not only by the CCT projects underway, but also by the technological development by those companies, such as Dravo, whose sorbent injection processes are not part of the CCT program.

The number of slurry and dry sorbent injection processes that have been successfully developed through the demonstration phase provides strong evidence that this class of SO_2 removal processes is technically feasible. The majority of the equipment required in the GSA process is the same as that required for many other processes. Therefore, there is no question as to the feasibility of all sub-processes that support the absorber.

The absorber used in the GSA process was specifically developed by FLS for heating/calcining solids and is used commercially for these applications. Therefore, any early problems with feeding and recovering the solids have been solved. The only remaining questions regarding feasibility are SO_2 removal efficiency and sorbent consumption. Experience at a utility plant test unit and the commercial installation at the Roskilde waste-to-energy plant demonstrates that the GSA process is feasible for SO_2 removal applications.

In summary, there is considerable experience on the GSA process that indicates it is technically feasible when used with U.S. coals. This CCT demonstration project is the final step in making the GSA process commercially proven for boilers fired with U.S. high-sulfur coal.

3.3.1.3 Resource Availability

All resources required for this project are available to the project. AirPol will provide the Participant's share of the project financing by way of equity and in-kind contributions.

The demonstration will have adequate coal and lime supply during the demonstration. Both resources will continue to be obtained through TVA's normal suppliers.

This program will involve the installation of a new, 10 MWe GSA system with appropriate facilities and scheduling flexibility to accommodate this project. The site selected for the proposed demonstration will provide an excellent opportunity to evaluate the technology in the situations that are likely to be encountered in commercialization of the technology. All appropriate resources can be made available to the site. In addition, adequate funds have been committed by the co-funder to cover its share of the estimated project costs.

3.3.2 Relationship Between Project Size and Projected Scale of Commercial Scale of Commercial Facility

The 10 MWe equivalent size of the demonstration plant is dictated by the size of the peripheral equipment available at the Shawnee Test Facility. The full scale commercial size unit applicable to industrial and utility boiler would be sized to treat the flue gas from a 100 MWe boiler. This represents a scale-up of 10 to 1 which is considered standard procedure in chemical engineering. For larger utility boilers, additional scale-up could be carried out or multiple modules could be used.

All ancillary equipment is available at the appropriate scale for all sizes of commercial utility and industrial boilers. Therefore, the only remaining scale-up will be for those items of equipment that are unique to the GSA process.

3.3.3 Role of the Project in Achieving Commercial Feasibility of the Technology

The GSA process has the potential to enhance the use of medium- and high-sulfur coals under conditions requiring compliance with environmental regulations. The commercialization of the GSA technology requires a comprehensive data base that demonstrates the SO_2 removal effectiveness, reliability and cost effectiveness of the technology. Commercialization of the technology also requires transfer of relevant data to the industry that needs the technology.

3.3.3.1 Applicability of the Data to be Generated

The data collected during the demonstration project will be adequate to fully characterize the process and to determine the impact of various parameters on the performance of the process. The following data will be measured either continuously or on an hourly basis:

- o Inlet gas conditions - temperature, pressure, flow rate, SO_2 content, HCl content, particulate content
- o Outlet gas conditions - temperature, pressure, flow rate SO_2 content, HCl content, particulate content.
- o Lime slurry - flow rate, solids content.
- o Recirculated flue gas - pressure, temperature, flow rate, chloride content.

These data, as well as other operating and analytical data, will be used to establish the correlation between SO_2 removal efficiency, waste product characteristics and major operating variables. A mathematical model relating SO_2 removal to the measured variables will be developed.

During the operational period, the consumption rates of lime, electric power and water will be measured and recorded. This will permit a comprehensive economic evaluation of the process.

With the operating data (and resulting model) and the economic data from this project, the Participant will be able to assess the commercial potential of the GSA process in U.S. coal-fired boilers.

3.3.3.2 Identification of Features that Increase Potential for Commercialization

The FGD systems that use lime or limestone are the standard technology for SO_2 removal. These systems remove about 90% of the SO_2 and usually produce a sulfite/sulfate sludge waste product. Spray dryers use a lime slurry which is sprayed into the flue gas duct or a special vessel. The design of the spray dryers makes it critical that evaporation is complete before the spray reaches the duct or vessel wall to avoid a wet solids build-up on the walls. This is accomplished by maintaining a very fine spray.

While other SO_2 removal systems exist, these two technologies are considered the primary competitors of GSA. Other processes, some of which regenerate rather than discard the sorbent, are available but are either much more complex or less developed or both. Dry sorbent injection is another set of processes that could compete where lower SO_2 removal rates and/or higher sorbent ratios are acceptable.

The GSA process offers several advantages over the competing processes. It is estimated by AirPol to be 40% cheaper than wet FGD and 20% cheaper than spray drying. Although estimates were not provided by the Participant, GSA offers even more cost advantages compared to the regenerable process. GSA is much simpler to build and operate than wet FGD and regenerable processes and requires much less space. Space requirements, operability and ease of installation are comparable to spray dryers and duct injection. However, the SO_2 removal capability of the GSA technology (90%) compares to that of wet FGD and the regenerable processes, while dry injection processes and spray dryers generally remove about 50 and 90% respectively. This high removal rate makes the GSA process suitable for use with high-sulfur coal, unlike the spray dryer or dry injection processes which are suitable only for low- and medium-sulfur coals.

In summary, GSA is expected to find commercial acceptance since it is the only semi-dry process which offers SO_2 removal rates comparable to the more costly and complex wet FGD systems. In addition, GSA offers relatively low sorbent consumption rates and may perform better than dry systems; it is both less costly and more effective than spray dryers.

3.3.3.3 Comparative Merits of Project and Projection of Future Market Acceptability

The GSA process is a viable alternative to wet or dry scrubbing or spray-dryers for SO_2 removal. Conventional (wet) FGD systems have large site space requirements, reduce plant availability, reduce plant electrical output and are high in capital costs. Dry and semi-dry systems are somewhat less capital intensive, but SO_2 removal efficiencies are somewhat lower. Dry systems generally remove about 50% of the SO_2, spray-dryers remove up to 90% of the SO_2, and wet FGD processes typically remove about 90% of the SO_2. For medium-sulfur coals dry and semi-dry systems use Ca/S ratios of 1.5 or more while wet systems use Ca/S ratios of 1.05 to 1.1. The relatively low SO_2 removal rate of dry and semi-dry systems makes them unsuitable for use with high-sulfur coals.

Compared to dry or wet FGD systems or spray-dryers, the GSA process offers several advantages. It is 20% less costly than the spray-dryer and 40% less than the cost of wet FGD systems. The GSA process is capable of 90% SO_2 removal at a low Ca:S ratio. This makes GSA suitable for use with high sulfur coal. In addition, GSA requires relatively little space and is simple to install and operate.

This demonstration project also has several site-specific advantages in addition to those process-related advantages which were described above. The site is ideally suited to this project. Since it is being carried out at a test facility, utilities, peripheral equipment and knowledgeable personnel are available. The 10 MWe project size is sufficiently large as to minimize scale-up problems, but small enough to hold project costs to a reasonable level. Although the project takes place at a test facility, it will treat flue gas from a fully operational utility boiler.

In summary, the site and project size are such that the results will be directly applicable to many industrial and utility boilers. If the expected performance and cost advantages of the GSA process are successfully demonstrated, market acceptance should occur rapidly.

4.0 ENVIRONMENTAL CONSIDERATIONS

The NEPA compliance procedure, cited in Section 2.2, contains three major elements: a Programmatic Environmental Impact Statement (PEIS); a pre-selection, project-specific environmental analysis; and a post-selection, site-specific environmental analysis. DOE issued the final PEIS to the public in November 1989 (DOE/EIS-0146). In the PEIS, results derived from the Regional Emissions Database and Evaluation System (REDES) were used to estimate the environmental impacts that might occur in 2010 if each technology were to reach full commercialization, capturing 100 percent of its applicable market. These impacts were compared to the no-action alternative, which assumed continued use of conventional coal technologies through 2010 with new plants using conventional flue gas desulfurization to meet New Source Performance Standards.

Next, the pre-selection, project-specific environmental review focusing on environmental issues pertinent to decision-making was completed for internal DOE use. The review summarized the strengths and weaknesses of each proposal against the environmental evaluation criteria. It included, to the extent possible, a discussion of alternative sites and/or processes reasonably available to the offeror, practical mitigating measures and a list of required permits. This analysis was provided for consideration of the Source Selection Official in the selection of projects.

To complete the final element of the NEPA strategy, the Participant (AirPol, Inc.) submitted to the DOE the environmental information volume specified in the PON. This detailed site- and project-specific information forms the basis for the NEPA document required of DOE. This document, prepared in full compliance with the Council on Environmental Quality regulations for implementation of NEPA (40 CFR parts 1500-1508) and DOE guidelines for NEPA compliance (52 FR 47662), must be approved before federal funds can be provided for any activity that would limit the choice of reasonable alternatives to the proposed action.

In addition to the NEPA requirements outlined above, the Participant must prepare and submit an Environmental Monitoring Plan (EMP) for the project. The purpose of the EMP is to ensure that sufficient technology, project, and site environmental data are collected to provide health, safety, and environmental information for use in subsequent commercial applications of the technology.

The expected performance characteristics and applicable market for the gas suspension absorption (GSA) system were used to estimate the environmental impacts that might result if this technology were to reach full commercialization in 2010. The REDES model was used to compare the impacts of the GSA technology for sulfur dioxide removal from flue gas to the no-action alternative.

Projected environmental impacts from commercialization of the GSA technology into national and regional areas in 2010 are given in Table 1. Negative percentages indicate decreases in emissions or wastes in 2010. Conversely, positive values indicate increases in emissions or wastes. These results should be regarded as approximations of actual impacts.

Table 1
Projected Environmental Impacts in 2010, GSA
(Percent Change in Emissions and Solid Wastes)

Region	Sulfur Dioxide	Nitrogen Oxides	Solid Wastes
National	-45	0	+19
Northeast	-65	0	+22
Southeast	-52	0	+26
Northwest	-10	0	+11
Southwest	-15	0	+11

Source: Programmatic Environmental Impact Statement (DOE/EIS-0146) November 1989.

As shown in Table 1, significant reductions of SO_2 are projected to be achievable nationally due to the capability of the GSA process to remove at least 90% of the SO_2 emissions from coal-fired boilers and the wide potential applicability of the process. The REDES model predicts greatest SO_2 reductions will be realized in the Northeast because of the large amount of coal-fired capacity there that can be retrofitted with the GSA process. The least impact occurs in the Northwest because of the minimal use of coal there. The REDES model predicts that solid waste would increase as much as 19% nationally. The solids are composed of gypsum, fly ash, and unreacted lime and this material is readily disposable. The national quadrants used in this study are depicted in Figure 3.

5.0 PROJECT MANAGEMENT

5.1 Overview of Management Organization

The project will be managed by AirPol's Vice President of Operations. He will be the principal contact with DOE for matters regarding the administration of the Cooperative Agreement. The DOE Contracting Officer is responsible for all contract matters and the DOE Contracting Officer's Technical Representative (COTR) is responsible for technical liaison and monitoring of the project.

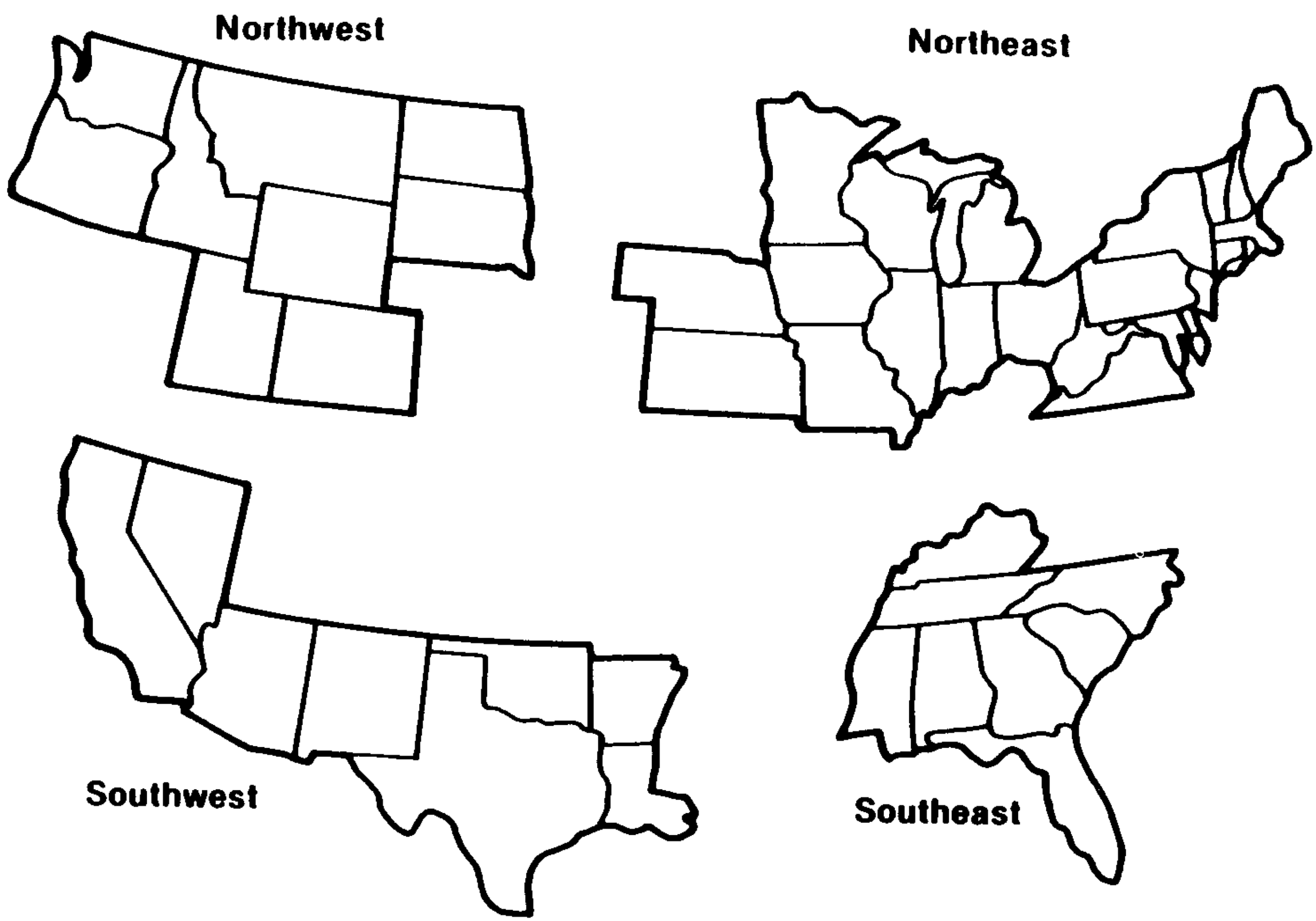

FIGURE 3. QUADRANTS FOR THE CONTIGUOUS UNITED STATES.

NO/18,677

The co-funding of the project will be provided by AirPol, with the backing of its parent company, FLS miljo, and the TVA. AirPol's V.P. of Operations will have overall responsibility for execution of the Cooperative Agreement. AirPol's Project Manager will be responsible for timely completion of the required tasks and will serve as the focal point in coordinating activities of the various team members.

5.2 Identification of Respective Roles and Responsibilities

DOE

The DOE shall be responsible for monitoring all aspects of the project and for granting or denying all approvals required by the Cooperative Agreement. The DOE Contracting Officer is DOE's authorized representative for all matters related to the Cooperative Agreement.

The DOE Contracting Officer will appoint a Contracting Officer's Technical Representative (COTR) who is the authorized representative for all technical matters and has the authority to issue "Technical Advice" which may:

- o Suggest redirection of the Cooperative Agreement effort, recommend a shifting of work emphasis between work areas or tasks, and suggest pursuit of certain lines of inquiry which assist in accomplishing the Statement of Work.

- o Approve those reports, plans, and items of technical information required to be delivered by the Participant to DOE under the Cooperative Agreement.

The DOE COTR does not have the authority to issue any technical advice which:

- o Constitutes an assignment of additional work outside the Statement of Work.

- o In any manner causes an increase or decrease in the total estimated cost, or the time required for performance of the Cooperative Agreement.

- o Changes any of the terms, conditions, or specifications of the Cooperative Agreement.

- o Interferes with the Participant's right to perform the terms and conditions of the Cooperative Agreement.

All technical advice shall be issued in writing by the DOE COTR.

Participant

AirPol will take the lead in the effort required for the successful execution of this project and act as the center of communication and the major coordinator to all the parties participating in the project. AirPol will also be responsible for fulfilling all the DOE reporting requirements as stipulated in the Cooperative Agreement.

AirPol's V.P. of Operations will be in charge of the overall project, and the prime decision maker in all phases of the project. He will be the principal representative of AirPol to DOE and provide supervision and guidance to all project management team members. The V.P. of Operations will report to the President of AirPol, Inc. ensuring top level attention to the project.

AirPol's Project Manager will be responsible for the timely completion of all tasks required for the project and will act as the focal point in steering the progress of the project, and in coordinating with DOE, TVA, FLS miljo, and all AirPol project team members. The Project Manager will maintain overall cost and schedule control of the project.

He will also provide supervision and guidance to the project design team and construction management group assigned to the project. The Project Manager will coordinate with the Contract Specialist on all procurement tasks and will interface with the Environmental Specialist on all environmental matters. The Project Manager will report regularly to the V.P. of Operations on the progress and performance of the project.

FLS miljo, AirPol's parent company and the inventor of the GSA process, will act as technical consultant to AirPol on design, operation and testing of the demonstration system.

As the test site host and a subcontractor to AirPol, the TVA will be responsible for the Phase III operation and testing activities. The TVA will also be responsible for the management of all resources required for plant operation such as manpower, fuel, plant utilities and reagent. The TVA will also be responsible for the management of by-product disposal.

The team members will interface with each other and with DOE as shown in Figure 4.

5.3 Summary of Project Implementation and Control Procedures

All work to be performed under the Cooperative Agreement is divided into three phases. These phases are:

o Phase I:	Design (6 months)	Budget Period 1
o Phase II:	Construction (8 months)	Budget Period 1
o Phase III:	Operation (12 months)	Budget Period 2

As shown in Figure 5, there will be no pauses or overlaps between phases.

Consistent with P.L. 100-446, DOE will obligate funds sufficient to cover its share of the cost of each budget period. Throughout the course of this project, reports dealing with the technical, management, cost, and environmental monitoring aspects of the project will be prepared by AirPol and will be provided to DOE. At the end of Phase II (budget period 1), a decision on whether or not to proceed with the project will be made by DOE.

5.4 Key Agreements Impacting Data Rights, Patent Waivers and Information Reporting

AirPol's incentive to develop this process is to realize retrofit business from, and produce new designs for, the utility and power boiler industry with respect to SO_2 and HCl abatement technology.

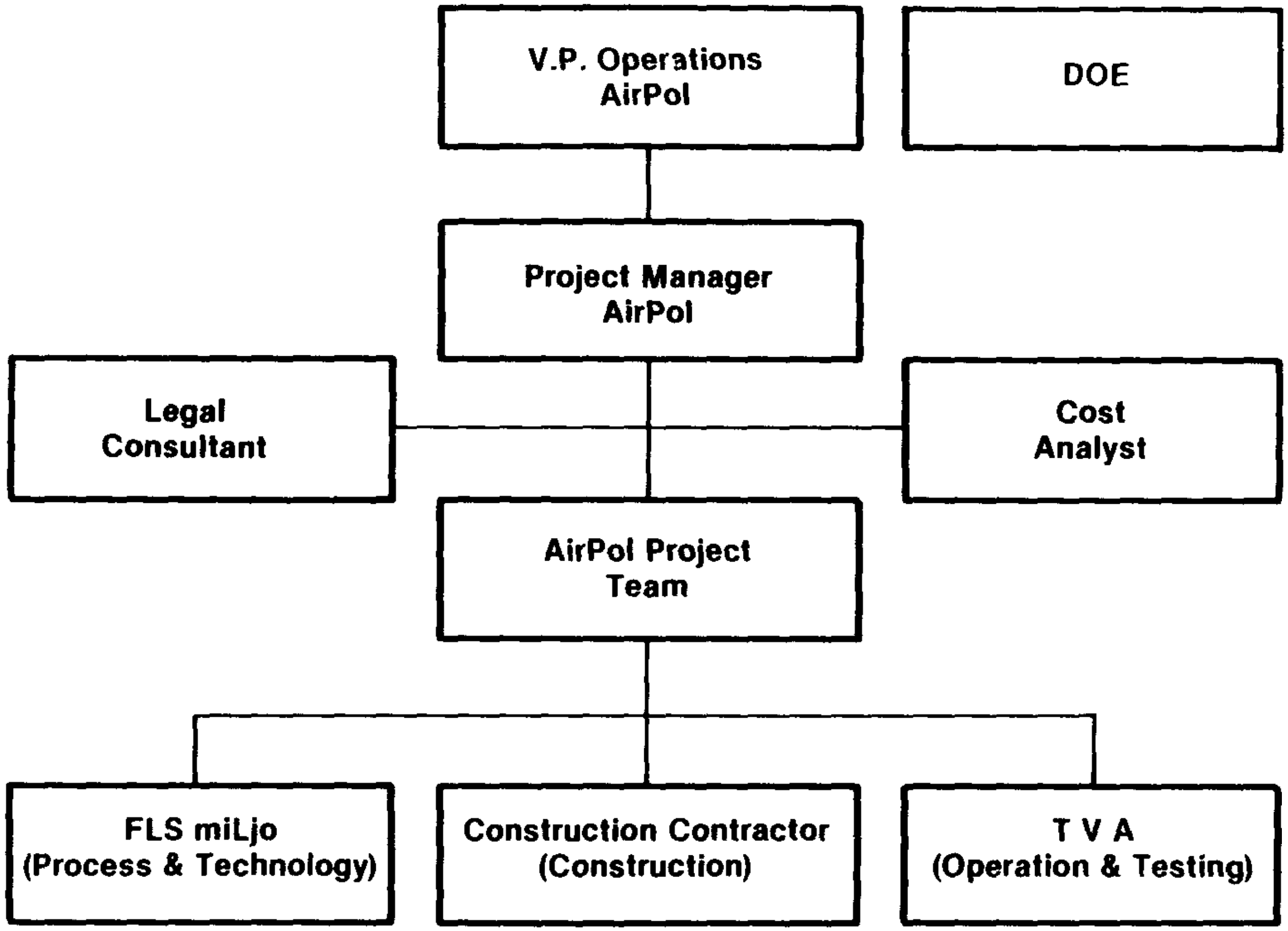

FIGURE 4. GSA DEMONSTRATION PROJECT ORGANIZATION.

NO./19,691

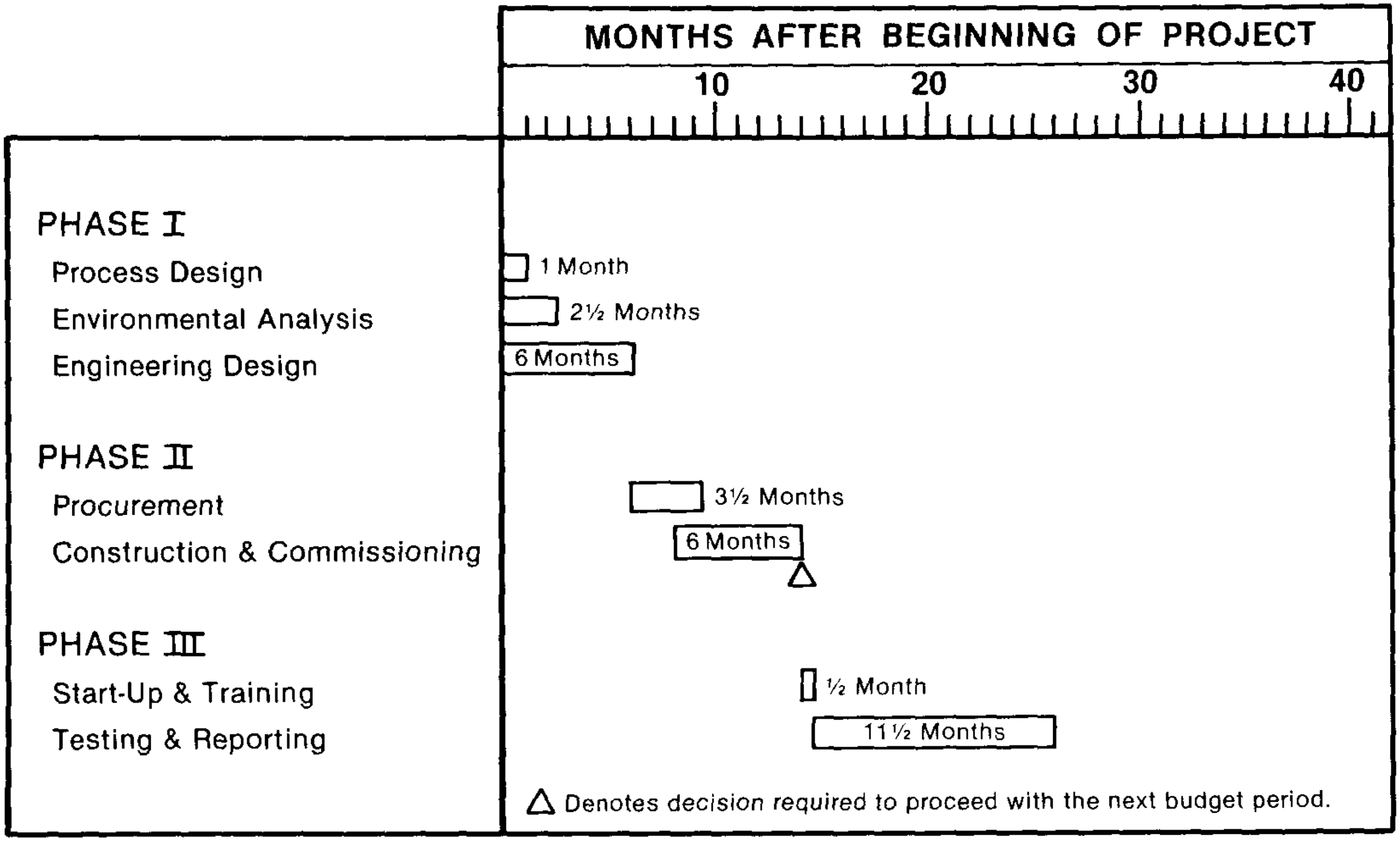

FIGURE 5. OVERALL AIRPOL SCHEDULE FOR GSA DEMONSTRATION PROJECT.

NO./19.690

The key agreements in respect to patents and data are:

- o Standard data provisions are included, giving the Government the right to have delivered, and use, with unlimited rights, all technical data first produced in the performance of the Agreement.
- o Proprietary data, with certain exclusions, may be required to be delivered to the Government. The Government has obtained rights to proprietary data and non-proprietary data sufficient to allow the Government to complete the project if the Participant withdraws.
- o A patent waiver may be granted by DOE giving AirPol ownership of foreground inventions, subject to the march-in rights and U.S. preference found in P.L. 96-517.
- o Rights in background patents and background data of AirPol and all of its subcontractors are included to assure commercialization of the technology.

AirPol will make such data, as is applicable and non-proprietary, available to the U.S. DOE, U.S. EPA, other interested agencies, and the public.

5.5 Procedures for Commercialization of Technology

Recognizing the potential market that could result from acid rain legislation, AirPol is committed to additional research and development expenditures in order to further develop the technology that will give it a significant share of this market in the 1990's.

The proposed demonstration unit would establish a documented, referenced test installation for AirPol's semi-dry technology enabling AirPol to market their GSA system to the utility industry in the United States, as well as a wide range of the industrial boiler market where high-sulfur coals are burned.

Forecasts of the FGD market for the combined utility and industrial boiler market in the United States (contract value of orders*) commencing with the year 1990 are as follows:

1990	1991	1992	1993	1994
$250	$300	$325	$375	$400

*(in millions)

AirPol has made a short-term plan and commitment to achieve a minimum of 10% penetration of that market, and a longer-term goal to achieve a 20% market share.

6.0 PROJECT COST AND EVENT SCHEDULING

6.1 Project Baseline Costs

The total estimated cost for this project is $6,920,679. The Participant's cash contribution and the Government share in the costs of this project are as follows:

	Dollar Share ($)	Percent Share (%)
PRE-AWARD		
Government	51,048	28.9
Participant	125,589	71.1
PHASE I		
Government	244,679	50.0
Participant	244,679	50.0
PHASE II		
Government	656,199	31.8
Participant	1,410,400	68.2
PHASE III		
Government	1,048,074	25.0
Participant	3,140,011	75.0
TOTAL PROJECT		
Government	2,000,000	28.9
Participant	4,920,679	71.1
	6,920,679	

Cost sharing contributions will be made as follows:

DOE:	$2,000,000	Cash
AirPol:	2,323,679	Cash
TVA:	2,597,000	In-kind

At the beginning of each budget period, DOE will obligate sufficient funds to pay its share of the expenses for that phase.

6.2 Milestone Schedule

The project will be completed in 26 months.

Phase I, which includes design and environmental analysis, will last for six months. Phase II (construction) will start immediately after Phase I and last eight months. Within Phase II, procurement will last three and one half months. Construction will start two months after long lead procurement and, along with commissioning, last for six months. Phase III (operations) start-up and training will start at the end of commissioning and last for two weeks. Testing and reporting will last for 11 1/2 months. All Phase III activities will be completed in one year.

6.3 Recoupment Plan

Based on DOE's recoupment policy as stated in Section 7.4 of the PON, DOE is to recover an amount up to the Government's contribution to the project. The Participant has agreed to repay the Government in accordance with a negotiated Repayment Agreement to be executed at the time of award of the Cooperative Agreement.